Buchner (Munich), on the tribe of Bantu negroes distributed through the whole of South-west Africa. Prof. Günther (Ansbach), on the latest investigations regarding the exact shape of the earth. Lieut. Wissmann, on his journey across Africa with Dr. Pogge. The oldest among the German African travellers now living, Dr. Rüppel, had come to Frankfort to greet Wissmann upon his return. The fourth Geographentag will be held at Munich.

FROM a paper by M. Smicroff on the climate of the Caucasus (published in the Caucasian *Izvestia*, and based on the researches of Dr. Wild on the temperatures in Russia), it is evident that although enjoying a warm climate, still the climate of the Caucasus, especially in the north, is quite continental. Thus, the average mean temperatures of the year are 5°·4 Cels. at Alexandropol, 8°·5 at Stavropol, 12°·6 at Tiflis, and 14°·3 to 14°·5 at Bakou, Lenkoran, Kutais, Poti, and Redut-kaleh; but the yearly range of the average diurnal temperatures is still (with the exception of the two last places) as much as 20 to 30 degrees, while in Central and Southern Russia it varies from 22 to 35 degrees. The highest temperatures observed on the Caucasus vary from 38°·5 at Tiflis, to 34°·4 at Poti; and the lowest from −25°·6 at Stavropol, to −17°·3 at Tiflis, and −6°·6 at Redut-kaleh. It is interesting to compare these temperatures with the +38°·8 and −62° observed at Yakutsk, and −63°·2 at Verkhoyansk. Altogether, it is only in Southern Transcaucasia that localities are found where the temperature does not fall below −10°, and the southern limit of the region beyond which temperatures lower than −20° are no longer found, runs from the Crimea to the Caucasus range, and along the northern slope of this last, towards Khiva, Tashkend, and Peking. The whole range of temperatures observed at Caucasian stations is 60°·4 at Stavropol, 55°·8 at Tiflis, 45°·9 at Bakou, 42°·1 at Poti, and 41°·6 at Redut-kaleh. Of course it is nothing in comparison with the range at Yakutsk, where the inhabitants must be accustomed to experience differences of temperature ranging a little more than 100° (from −62° to +38°·8). But still it is large enough, especially for the places situated on the plateaux. High-level meteorological stations are established at Goudaur (2156 metres above the sea-level) and Kvi am (2362 metres). Their average yearly temperatures respectively are 4°·1 (−8° in February and 14°·3 in August) and 1°·1 (−14° in January and 12°·3 in August).

THE last number of the *Izvestia* of the Russian Geographical Society contains an elaborate paper, by M. Malakhoff, on the anthropology of the Vyatka region; a description of inscriptions on rocks on the Yenisei, with drawings, by M. Schukin; a note on old Russian geography, by M. Arsenieff; an account on M. Balkashin's researches into the Kirghiz, being a most valuable addition to our very imperfect knowledge of them. The author comes to the conclusion that the Kirghiz are not a separate nation, but a federation of several nomad tribes who inhabited Southern Russia, the Gobi, the neighbourhoods of Dalay-nor, the sources of the Black Irtish, and the shores of the Baikal, who were mingled together by Genghiz Khan and his successors. M. Grigorieff contributes a note in which he shows that Henriette Island, which was discovered by the *Jeannette*, is only the land which was sighted by Hedenström and Sannikoff from New Siberia in 1810, and that Bennett Island was seen by Sannikoff from the northern coast of New Siberia in 1811. There can be no doubt also that the land discovered by Sannikoff to the north-west of the northern extremity of the Kotelnyi Island exists in reality, but is more distant than Sannikoff supposed. This land, which was shown in dotted lines on older maps, but disappeared since Wrangell and Anjou's journeys, ought to be reintroduced on our maps. The same number contains a note on the map of Bokhara of the Greek Vatalsi, a necrological notice of M. Tchoupin, several notes, and a new edition of the complete bibliography of the Amoor, by M. Bousse. One of the notes contained new astronomical determinations and hypsometrical measurements on the Yu-tschou, by Dr. Fritsche; the Siao-Utai-shan proved to be only 9500 feet high, instead of the 11,452 feet given by Mellendorf.

ACCORDING to intelligence from Tashkend, dated March 31, received by the *Cronstadt Courier*, it is in contemplation to send two Russian Exploring Expeditions into Central Asia during the coming summer. The ostensible object of one is to survey part of the Pamir Steppe and fix certain points astronomically, with the object of connecting the Russian surveys with the English. The purpose of the other is to determine the astronomical position of places on the Oxus from the points of passage in its upper course down as far as Khiva, in fact the whole course of the river.

FROM M. De Lesseps's examination of the ground through which it is proposed to let the waters of the Mediterranean into the Tunisian and Algerian Chotts, he concludes that the scheme is perfectly practicable, and that there will be no difficulty as to boring and excavating. The size of the proposed inland sea will be fourteen times that of the Lake of Geneva.

THE SOARING OF BIRDS[1]

THE circling, soaring flight of birds on stiff, outspread wings appears to me a much more complex problem, and less easy of explanation, than that of motionless hovering (poising) At the same time it has certain definite and characteristic features, which must depend upon and connote certain definite aërial conditions, and which should therefore afford us so many hints toward the solution. The whole phenomenon has been very clearly described in NATURE (vol. xxiii. p. 10) by Mr. S. E. Peal, who appears to have had grand opportunities of observing it at Sapakati in Assam. [The explanation which he gives is, however, insufficient, because he does not show how the bird in falling with the wind can acquire greater "impetus" *relative to the air* than it would if the air were still. But such greater "impetus" is necessary if the bird is to rise to a greater height than it would reach in still air.]

The most typical instance that I have observed was on January 8, 1882, near King's Lynn, in Norfolk. The whole country for many miles round is flat, broken only by trees, buildings, and sea walls or river embankments. The wind was strong from the south. The birds (large gulls) were drifting away northwards towards the Wash, circling as they drifted on stiff, outspread wings at a height of 200 or 300 feet, and apparently rising higher. The level nature of the land forbade the notion that the wind had received an upward throw from any fixed obstacle in its path (though I shall show below that there may be upward currents in the air without the presence of a fixed obstacle).

The circling appears to begin about 100 or 200 feet above the ground. A strong wind is a constant and (presumably) necessary condition. The bird descends with the wind, and then circles round to right or left, and rises against the wind to a greater height than it had before. Now if the whole mass of air were moving together horizontally with the same velocity throughout, this action would be wholly inexplicable, for the bird would feel no more wind in one direction than in another, and indeed would have no evidence of the existence of any wind at all except in glancing at objects on the earth. The fact that the earth is slipping away under the air in a certain direction does not affect the bird's relation to the air, and gives no reason why the bird should fall or rise at one phase of its circle more than at another. Still less does it furnish an explanation of the bird's progressive ascent. We may therefore infer as highly probable that the air in which the birds are circling does not move in a mass, but that there is some differential movement in it which makes a great difference to the bird, whether it rises or falls with or against the wind.

I think there are at least two types of differential movement in the upper air which admit of demonstration, and which should be tested in turn to see if either of them can give the meaning of the phenomenon of circling.

(1.) First, there is almost always *a greater velocity in the higher strata* of the air than in the lower. The lower strata are delayed by friction on the earth's surface, and the higher strata outrun them; just as the water of a brook is delayed by friction against its bank, but flows faster in mid-stream.

(2.) Secondly, where currents override or run past one another there is generally some *rolling* between them. This may be seen near the edge of any stream of water if the surface is smooth enough to exhibit the little swirls and whirlpools that are formed between the swifter and slower currents. In the air it may be seen on a grand scale on almost any windy day when there are separate floating clouds in the sky. Looking at right angles to the direction of the wind, each cloud is seen to have a systematic movement within itself: the rearward skirts of the cloud are climbing up its sloping back, often with little rolling curls: the top of the cloud is rolling over like a breaker in the act of tumbling on the beach. Each cloud is in fact the scene of a travelling vortex in the air revolving round a more or less horizontal axis. And the persistency with which such a cloud will preserve its individual identity indicates the persistency of the vortex. In the comparatively lower regions of the air it may be difficult to demonstrate the presence of such vortices, but similar causes are present, and it cannot be doubted that similar effects are produced and that such vortices, possessing a proportionate degree of persistency, are generated in those regions of the air which are within the range of the habitual flight of circling birds.

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[1] Lord Rayleigh's valuable letter on this subject (NATURE, vol. xxvii. p. 534) gives me confidence in offering the following considerations, which I had prepared last February, and have submitted to two or three mathematical friends. I congratulate myself on finding my own views in such close agreement with Lord Rayleigh's.—H. A.

Let us see what effect these conditions (1) and (2) separately would have upon the circling flight of a bird.

(1.) First, let us take horizontal currents increasing in velocity the higher they are above the earth; and suppose a bird at the highest point of one of its gyrations, when it has mounted against the wind and is wheeling to one side or the other, preparatory to the descent with the wind which is to give it sufficient velocity for another rise (but which could not enable it to rise to the same height as before if the air had no internal movement, for there would be no self-renewing force to neutralise the ever-new force of gravity and the perpetual friction of the air). Let us regard the *air at the level of the bird, at this turning-point, as still.* Then, relative to this point, the lower strata of air have a horizontal velocity in the opposite direction to the wind (as perceived on earth); and the bird in falling apparently down the wind will really be meeting stronger and stronger adverse currents, and when it has reached the lowest point of the "circle," it will have a greater horizontal velocity relative to the air at that level than if the whole air through which it has fallen had been still. Therefore, in virtue of its greater horizontal velocity relative to the air (which is accompanied by increased air-resistance), the bird will be subject to a greater force upon its wing-surface, and will therefore be able to mount higher (*cæteris paribus*) than if it had fallen through still air. But (instead of "*cæteris paribus*") suppose the bird, as it rises, wheels gradually round and faces the wind. Then, in rising, it will enter successive strata of air having successively greater and greater velocity relative to itself (the bird) than if the air had no internal movement, and therefore the air-resistance, which is the lifting force, will ever be greater than that due to the height gained by the bird if in still air; and therefore the bird will be able to rise yet higher. But this manœuvre of wheeling to face the wind in rising will cost some time, during which gravity ceases not to act; it will also cost some friction and a slight loss of horizontal velocity, and the question is whether these losses are sufficient to destroy the advantage above described. This is a problem for the mathematicians to solve.

It seems difficult to imagine that within the narrow limits of the actual rise and fall of the bird at the different phases of its circle, there should be sufficient difference of velocity of upper and lower air-currents, to account for such a gain of elevation as Mr. Peal mentions (from 10 to 20 feet at each lap). We require, however, to know the vertical height of the bird's fall and subsequent rise. I have not seen any estimate of this, but, judging from Mr. Peal's diagram, the bird's fall appears no greater than its gain of elevation (10 or 20 feet).

Still it appears from the foregoing considerations that the bird will gain support by falling with the wind and rising against it, when the upper wind is stronger than the lower.

This result suggests that a bird might with like effect make use of two collateral currents of different velocity. Suppose two currents, fast and slow, side by side, flowing in the same direction. The bird may fall with the slow current, and so acquire a certain horizontal velocity. Then let it wheel round against the swift current, and it will be able to rise against it to a height due to the greater horizontal velocity between bird and air. Having reached full height, let it again wheel round into the slow current and recover by a sloping descent therein the horizontal velocity it has lost, which, when recovered, will enable it to mount again against the fast current.

Thus it would appear that a bird can take advantage of alternate fast and slow currents, whether collateral or superposed, rising against the fast and falling with the slow, to maintain itself in the air, while partaking in the general drift of the wind, without flapping its wings.

(2.) In the next case to be considered, we have to deal not with horizontal currents, but with the rotatory currents of rolling masses of air. A mass of air rolling about a horizontal axis will have descending currents in its front, and ascending currents in its rear. The former can be of no use to the bird for the purpose of support. The bird must keep in the rear of the roll, where it will find an upward slanting current. In a high wind this current would probably be strong enough to support the bird in motionless poise (relative to the earth), but this could only be for a few seconds, because the whole vortex is travelling rapidly with the wind (of which it forms a part) and would speedily pass and leave the poised bird behind at the mercy of the downward currents in the van of the next advancing vortex. How then is the bird to remain in the upward current, and at the same time to maintain a high velocity relative to the air in which it moves? It can only be done by circling. The bird must face the current in rising, and as it approaches at once the outskirts of the current and the limits of its own momentum (relative to the air) it must wheel round (—indeed it must have begun to wheel while rising—) and fall down the wind, for the double purpose of recovering its spent velocity and of overtaking the receding vortex.

In falling down the wind, the bird will pass out of a stronger into a weaker current, and will be able to take advantage of the difference (regarded horizontally), just as in the case (already considered) of horizontal currents of different velocity. But regarded vertically the descent into the weaker current will be a *disadvantage. However, it is clear that under these conditions* there will be no difficulty about the bird's support in air by a circling flight without stroke of wing.

But there is still a difficulty with regard to the progressive ascent of the bird. Mr. S. E. Peal (NATURE, vol. xxiii. p. 10) testifies that the pelican, adjutant, vulture, and cyrus rise circling from 100 or 200 to as much as 8000 feet. Can it be supposed that a rolling vortex of air would have equal range or climb to such a height? Swirls formed at the edge of a deep stream of water are seen to be drawn obliquely away from the side towards mid-stream, and I suppose that an aërial vortex with horizontal axis will in like manner be drawn obliquely upwards into the more rapid air. Moreover I remark that Mr. Peal's observations were made on the coast, and that his diagram represents the birds as rising on a wind blowing up the country towards the hills. Such a wind would have a general upward slant, and any rolling of the air would have the same slant to begin with and to rise from, so that a bird keeping to the (supposed) vortex would rise with it to the same height.

The same principles which we have found useful in dealing with the regular and rhythmical phenomenon of circling flight will, I think, help us to understand the general case of irregular sailing flight, like that of the albatross following a ship, as described by so many writers (*e.g.* the Duke of Argyll, "Reign of Law," fifth edition, pp. 153-4). This general case may be accounted for by (1) irregular alternations (either in strength or direction) of horizontal air-currents; or (2) irregular upward currents.

Currents alternating in strength are equivalent, in relation to any intermediate point, to currents alternating in direction.

To take an extreme, almost imaginary, case: let us suppose a bird on outspread wings exposed alternately to the force of exactly opposite winds. To each in turn the bird will offer the sloping under-surface of its wings, and by each in turn it will be at once uplifted and pushed back, but each will counteract the backward push of the other, while each will reinforce the other's uplifting effort. The result will be that the bird will rise in a wavy line without any effort of its own beyond what is required to keep its wings rigid, and to present them favourably to the alternate winds.

Now suppose the whole air to be travelling horizontally in a direction at right angles to the two opposite currents. This supposition will not affect the lifting power of those opposite currents, but it will make it necessary for the bird (if it is not to be swept away by the travelling air) to sacrifice some of the height it might gain for the sake of making head against the general drift of the wind. This is no longer an extreme or imaginary case, but one of very frequent occurrence. It is simply that of oscillating gusts in a high wind. The air is full of sidelong rushes of wind (probably parts of neighbouring vortices). See how the vane of a weathercock oscillates. A sidelong rush means fresh velocity relative to the bird in a new direction. The bird by a tilt of the wing can instantly convert that fresh air-pressure into a lifting force and rise upon it. And if these rushes of wind come alternately (as in an irregular fashion they are sure to do) from right and left, the bird can take advantage of their alternation to rise higher and higher, or at least to remain floating, without more effort than that which is required to give the due slope to its wings to make the most of every gust.

Next suppose the whole air with its two alternate opposite currents (as above) to be travelling horizontally in the same direction as one of the two opposite currents. Whether this supposition represents a possible state of things I hardly know, but it would correspond in some measure with the commonly observed phenomenon of a succession of alternate gusts and lulls in the wind. Under these conditions, if the air-movement be all horizontal, it is difficult to see how the bird can turn the alternate gusts to advantage, unless it can alternate its own direction accordingly, stemming the gust and wheeling round to fall back with the lull. The bird then would either circle or would follow a wavy course oblique to the direction of the wind. But I imagine that alternate gusts and lulls (as felt, say, at the top of an observatory) are generally caused by a succession of vortices, of which only one phase at a time is present to the observer. These vortices will be infinitely various in the direction of their axes and currents, and it is useless to try and imagine their relative positions. Probably the sea-birds, with their æons of inherited experience, have acquired an instinctive perception of the probable sequences and correlations of air-streams and air-swirls, and are thereby guided so to steer their course, selecting the upward and avoiding the downward currents, as to gain the greatest possible advantage of lifting force that those currents can afford, to the great economy of their muscular strength, which would otherwise have to be spent in the labour of the wing.

In reading of the way in which albatrosses and other large sea-birds will follow a ship at sea with little or no flapping of the wings, it has occurred to me that the great obstacle which the ship herself offers to the wind must of necessity give the wind an upward throw and originate a vortex in the air, possibly large enough and persistent enough to be useful to the birds. If the ship be a steamer, the drift of smoke from the funnel will indicate approximately the path of the retiring vortex. It is long since I have had any opportunity of observing, but I well recollect that the gulls used often to be seen in close relation to the smoke that drifted to leeward of the steamer. It is true that any chance morsels of biscuit, &c., thrown from the steamer would probably be thrown to leeward, and this might help to determine the position of the expectant gull.

Again, at sea, the ocean waves themselves, such as roll in from the Atlantic to the Land's End, must throw the wind into rolling vortices, which would afford slant upward currents. The slant, though very flat, might well be sufficient for the purpose of support to the long-winged sea-birds that know how to use it.

On land, countless obstacles impede the lower wind and tend to throw the air into a roll.

Bearing in mind, then, the perpetual variation in strength and direction of current in a high wind, the whirls and gusts, and veering flaws, and seeing how it is possible for the bird to utilise every such variation (except a downward current) to the purpose of its bodily support, we may, I think, obtain some insight into the agency whereby the birds accomplish their marvellous feats of soaring and sailing, upborne upon stiff-strained, motionless wings.

Further observations however are required for the full solution of the problem which I have here only tentatively approached. HUBERT AIRY

Woodbridge, February 28

SOME POINTS IN ELECTRIC LIGHTING[1]

THE science of lighting by electricity was divided by the lecturer into two principal parts—the methods of production of electric currents, and of conversion of the energy of those currents into heat at such a temperature as to be given off in radiations to which the eye was sensible. The laws known to connect together those phenomena called electrical, were essentially mechanical in form, closely correlated with mechanical laws, and might be most aptly illustrated by mechanical analogues. For example, the terms "potential," "current," and "resistance," had close analogues respectively in "head," "rate of flow," and "coefficient of friction" in the hydraulic transmission of power. Exactly as in hydraulics head multiplied by velocity of flow was power measured in foot-pounds per second, or in horse-power, so potential multiplied by current was power and was measurable in the same units. Again, just as water flowing in a pipe had inertia and required an expenditure of work to set it in motion, and was capable of producing disruptive effects if that motion were too suddenly arrested, so a current of electricity in a wire had inertia: to set it moving electromotive force must work for a finite time, and if arrested suddenly by breaking the circuit the electricity forced its way across the interval as a spark. Corresponding to mass and moments of inertia in mechanics there existed in electricity coefficients of self-induction. There was, however, this difference between the inertia of water in a pipe and the inertia of an electric current—the inertia of the water was confined to the water, whereas the inertia of the electric current resided in the surrounding medium. Hence arose the phenomena of induction of currents upon currents, and of magnets upon moving conductors—phenomena which had no immediate analogues in hydraulics.

The laws of induction were then illustrated by means of a mechanical model devised by the late Prof. Clerk Maxwell.

In the widest sense, the dynamoelectric machine might be defined as an apparatus for converting mechanical energy into the energy of an electrostatic charge, or mechanical power into its equivalent electric current through a conductor. Under this definition would be included the electrophorus and all frictional machines; but the term was used in a more restricted sense, for those machines which produced electric currents by the motion of conductors in a magnetic field, or by the motion of a magnetic field in the neighbourhood of a conductor. The laws on which the action of such machines was based had been the subject of a series of discoveries. Oersted discovered that an electric current in a conductor exerted force upon a magnet; Ampere that two conductors conveying currents generally exerted a mechanical force upon each other: Faraday discovered—what Helmholtz and Thomson subsequently proved to be the necessary consequence of the mechanical reactions between conductors conveying currents and magnets—namely, that if a closed conductor moved in a magnetic field, there would be a current induced in that conductor in one direction, if the number of lines of magnetic force passed through the conductor was increased by the movement; in the other direction if diminished. Now all dynamoelectric machines were based upon Faraday's discovery. Not only so; but however elaborate it might be desired to make the analysis of the action of a dynamo-machine, Faraday's way of presenting the phenomena of electromagnetism to the mind was in general the best point of departure. The dynamo-machine, then, essentially consisted of a conductor made to move in a magnetic field. This conductor, with the external circuit, formed a closed circuit in which electric currents were induced as the number of lines of magnetic force passing through the closed circuit varied. Since, then, if the current in a closed circuit was in one direction when the number of lines of force was increasing, and in the opposite direction when they were diminishing, it was clear that the current in each part of such circuit which passed through the magnetic field must be alternating in direction, unless indeed the circuit was such that it was continually cutting more and more lines of force, always in the same direction. Since the current in the wire of the machine was alternating, so also must be the current outside the machine, unless something in the nature of a commutator was employed to reverse the connections of the internal wires in which the current was induced, and of the external circuit. There were then broadly two classes of dynamoelectric machines—the simplest, the alternating-current machine, where no commutator was used; and the continuous-current machine, in which a commutator was used to change the connection with the external circuit just at the moment when the direction of the current would change. The theory of the alternate-current machine was then explained, and it was proved that two independently-driven alternate-current machines could not be worked in series, but that they might be worked in parallel circuit, and hence were quite suitable for distribution of electricity for lighting without the necessity of providing a separate circuit for each machine.

It was easy to see that, by introducing a commutator revolving with the armature, in an alternate-current machine, and so arranged as to reverse the connection between the armature and the external circuit just at the time when the current would

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[1] Abstract of lecture delivered at the Institution of Civil Engineers on Thursday evening, April 5, by Dr. John Hopkinson, F.R.S., M.Inst.C.E.